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(54) **SOLID-STATE IMAGING DEVICE AND METHOD OF MANUFACTURING THE SAME**

**FESTKÖRPER-BILDAUFNAHMEVORRICHTUNG UND VERFAHREN ZUR HERSTELLUNG  
DERSELBEN**

**DISPOSITIF D'IMAGERIE A SOLIDE ET PROCEDE DE FABRICATION DE CE DISPOSITIF**

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## Description

### FIELD OF THE INVENTION

The present invention relates to a solid state image pickup device according to the preamble of claim 1 known from JP-A-59-90467, and a method of manufacturing the same.

### BACKGROUND OF THE INVENTION

A solid state image pickup device is constructed of a plurality of pixels of image pickup elements each having a photosensitive section. In each image pickup element, light incident to a light receiving section is converted into electric charge signal by the photosensitive section (e.g., a photodiode). This electric charge signal is outputted from a charge transfer section of the solid state image pickup device.

As a method of improving the light reception sensitivity of such a solid state image pickup device without enlarging a light receiving section, a light converging lens is mounted above a photodiode (photosensitive section) to converge external light onto the photosensitive section.

A conventional method of manufacturing a solid state image pickup device having a light converging lens will be described with reference to Figs. 13A to 13D.

As seen from Fig. 13A, a plurality of photosensitive sections (photodiodes) 2 are first formed on the surface of a semiconductor substrate 1 at predetermined areas. The surface of the photodiodes 2 is covered with a passivation film 3. Color filters 4<sub>1</sub>, 4<sub>2</sub> and 4<sub>3</sub> are formed on the surface of the passivation film 3, using a dying film such as gelatin. The color filters 4<sub>1</sub>, 4<sub>2</sub> and 4<sub>3</sub> are red, green, and blue, respectively. A passivation film 5 is deposited on the surface of these color filters 4<sub>1</sub>, 4<sub>2</sub> and 4<sub>3</sub>.

Next, as seen from Fig. 13B, a photoresist film 6A is formed over the whole surface of the passivation film 5. The photoresist film 6A is patterned to form a photoresist film 6 above each photodiode 2.

Thereafter, as shown in Fig. 13C, light 7 is applied to the photoresist films 6 to make them transparent.

Then, as shown in Fig. 13D, the transparent films 6 are thermally deformed to form light converging lenses 6'.

Figs. 11A to 11C show a conventional solid state image pickup device manufactured by the above-described method. Fig. 11C is a plan view, Fig. 11A is a cross sectional view taken along the A<sub>5</sub>-A<sub>5</sub>' of Fig. 11C, and Fig. 11B is a cross sectional view taken along line B<sub>5</sub>-B<sub>5</sub>' of Fig. 11C. Fig. 11A corresponds to Fig. 13D.

Another conventional manufacturing method will be described with reference to Figs. 14A to 14D.

The processes up to forming a passivation film 5 shown in Fig. 11A are the same as those described with Fig. 13A. A transparent film 106 to form light converging lenses 106' (refer to Fig. 14D) is formed on the passiva-

tion film 5.

Next, as seen from Fig. 14B, a photoresist layer 107A is formed on the transparent film 106. The photoresist layer 107A is patterned by means of a photoetching method, to form a photoresist film 107 patterned so as to form light converging lenses. Thereafter, as seen from Fig. 14C and 14D, the transparent film 106 and photoresist film 107 are etched by means of an anisotropic etching (e.g., RIE). The shape of the photoresist film 107 is therefore transferred to the transparent film 106 to form the light converging lenses 106'. The plan view and cross sectional view along line B<sub>5</sub>-B<sub>5</sub>' of this device are shown in Figs. 11C and 11B.

As shown in Fig. 14B, the photoresist film 107 of a solid state image pickup device manufactured by the method explained with Figs. 14A to 14D is formed on a flat passivation film 5. Therefore, the film thickness is substantially the same both in the X- and Y-directions. Thus, the curvatures in the X- and Y-directions are determined by the shape of the photoresist film 107 patterned so as to form the light converging lenses. The light convergence efficiency in the direction along line A<sub>5</sub>-A<sub>5</sub>' of the light converging lens 6' (106') shown in Fig. 11A is good because light is refracted by the light converging lens 6' and directed to the center of the photodiode 2. However, the light convergence efficiency in the direction along line B<sub>5</sub>-B<sub>5</sub>' is not so good because of a so-called "circular aberration" phenomenon caused by a larger curvature at the plane along line B<sub>5</sub>-B<sub>5</sub>' of the light converging lens 6' (106') than that along line A-A. Specifically, as seen from Fig. 12 showing the lens effects, light in the X-direction (B-B direction) can be sufficiently converged, but light in the Y-direction (A-A direction) cannot be sufficiently converged. Therefore, an effective light convergence area 9 becomes small. In other words, the light convergence of the light converging lens 6 becomes small.

If the curvature is set so that light in the Y-direction can be sufficiently converged, the length of each pixel becomes greater in the X-direction than in the Y-direction. Therefore, contrary to the above-described case, light in the X-direction cannot be sufficiently converged. Most of light near each photodiode cannot be used accordingly. This is serious particularly for a PAL method having more pixels in the vertical direction than the horizontal direction.

As described above, a conventional device cannot obtain a sufficiently large effective light convergence area 9 (Fig. 12). Therefore, if the ratio of an X-direction width to a Y-direction width of the micro light converging lens 6' (106') changes, the light converging lens effects in the Y-direction may disappear in some cases. Namely, both opposite areas in the Y-direction of the photodiode 2 may become an invalid light convergence area 10. As a result, light incident to the invalid light convergence area 10 may enter adjacent photodiodes, resulting in a problem of increased color crosstalk, smear, and the like.

It is conceivable that the curvature is made small by thinning the film thickness of the light converging lens 6' (106') at the cross section in the Y-direction or along line B<sub>5</sub>-B<sub>5</sub>. However, this essentially makes small the curvature of the light converging lens at the cross section in the X-direction or along line A<sub>5</sub>-A<sub>5</sub>. The effective light convergence area therefore becomes small. If the length in the X-direction of the photodiode is made large to compensate for the reduced effective light convergence area, the problem of increased smear will occur.

#### SUMMARY OF THE INVENTION

JP-A-59-90467 discloses a solid state image pickup element wherein a convex condenser lens is located on each photodiode. The radius of curvature of the lens is selected suitably taken the thickness and the size of the lens, the size of the photodiode, the distance between the lens and the photodiode, and the reflective index of the lens and its background layer into account.

JP-A-110666 discloses manufacture of solid state image sensing device.

Therein, thermoplastic resin on a transparent material layer is transformed and the transparent material layer is processed by reflecting the shape of the transformed thermoplastic resin layer.

JP-A-2248074 discloses a collar solid state image sensing element.

According to this document cylindrical lens patterns equal to long narrow protrudent patterns in width are made to overlap the protruding patterns on a collar filter respectively along a lenswise direction such a manner that the lens patterns are made to deviate from the protruding patterns toward a center side respectively except that located at the center so as to restrain the incident light volume difference between sensing parts located at the center and an end.

In JP-A-60233952 a solid state image subdevice is recited. In this subject matter a solid state image pickup device, a condenser lens of small curvage radius is simply formed by laminating lens materials.

The present invention has been made in consideration of the above circumstances. It is therefore an object of the present invention to provide a solid state image pickup device and a method of manufacturing the same, capable of obtaining a high light reception sensitivity irrespective of the size of each pixel.

This object is achieved by the select state pickup image device of claim 1, and the corresponding manufacturing methods of claims 18 and 19, respectively.

According to the solid state image pickup device of the present invention, a suitable curvature or thickness of a light converging lens is set. Therefore, light incident to the light converging lens either in the row direction or in the column direction, can be converged efficiently to the corresponding photosensitive section, considerably improving the light reception sensitivity.

According to the method of manufacturing a solid

state image pickup device of the present invention, a strip layer is formed above photosensitive sections disposed in the column line to form light converging lenses by directly or indirectly using the strip layer. Therefore, it is possible to control the curvature or thickness of a light converging lens independently at cross sections in the row and column directions, and to obtain a solid state image pickup device capable of efficiently converging incident light in the row and column directions to the photosensitive section.

In the solid state image pickup device of the present invention, photosensitive sections of respective solid state image pickup elements are disposed in a matrix shape, and each light converging lens is positioned above each photosensitive section. The curvatures of each light converging lens, i.e., a first curvature at the cross section in the row direction of the matrix and a second curvature at the cross section in the column direction, are set to such values that light incident to each light converging lens in the row and column directions is directed to the corresponding photosensitive section. Therefore, irrespective of the shape of a photosensitive section, for example, irrespective of different side lengths in the row and column directions, light incident to each light converging lens in the row and column directions is directed to the corresponding photosensitive section.

According to the solid state image pickup device of the present invention, a desired thickness of a light converging lens is set. Therefore, light incident to each light converging lens in the row and column directions, is directed to the corresponding photosensitive section, similar to the above-described device, irrespective of the shape of a photosensitive section, for example, irrespective of the side lengths in the row and column directions.

According to the method of manufacturing a solid state image pickup device of claim 18 of the present invention, a strip layer is formed above a plurality of photosensitive sections disposed in the row direction. An outer portion of each light converging lens is formed on the strip layer. Therefore, the curvature of each light converging lens can be controlled independently at cross sections in the row and column directions. It is therefore possible to obtain a solid state image pickup device having light converging lenses capable of directing light incident in the row and column directions to the corresponding photosensitive sections.

According the method of manufacturing a solid state image pickup device of claim 19 of the present invention, a strip layer is formed above a plurality of photosensitive sections disposed in the row direction. A lens shape is formed on the strip layer by using the strip layer, the thickness of the lens form being controlled independently at cross sections in the row and column directions. The lens shape is transferred to form a light converging lens. Therefore, it is possible to obtain a solid state image pickup device having suitable controlled

thicknesses at cross sections in the row and column directions.

#### BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1A is a cross sectional view taken along line A<sub>1</sub>-A<sub>1</sub>, of a solid state image pickup device according to a first embodiment of the present invention;  
 Fig. 1B is a cross sectional view taken along line E<sub>1</sub>-E<sub>1</sub>, of the solid state image pickup device of the first embodiment;  
 Fig. 1C is a plan view of the solid state image pickup device of the first embodiment;  
 Fig. 2 is a plan view explaining the advantageous effects of the first embodiment;  
 Figs. 3 and 4 show processes of a method of manufacturing the solid state image pickup device of the first embodiment;  
 Fig. 5A is a cross sectional view taken along line A<sub>2</sub>-A<sub>2</sub>, of a solid state image pickup device according to a second embodiment of the present invention;  
 Fig. 5B is a cross sectional view taken along line B<sub>2</sub>-B<sub>2</sub>, of the solid state image pickup device of the second embodiment;  
 Fig. 5C is a plan view of the solid state image pickup device of the second embodiment;  
 Fig. 6A is a cross sectional view taken along line A<sub>3</sub>-A<sub>3</sub>, of a solid state image pickup device according to a third embodiment of the present invention;  
 Fig. 6B is a cross sectional view taken along line B<sub>3</sub>-B<sub>3</sub>, of the solid state image pickup device of the third embodiment;  
 Fig. 6C is a plan view of the solid state image pickup device of the third embodiment;  
 Fig. 7A is a cross sectional view along line A<sub>4</sub>-A<sub>4</sub>, of a solid state image pickup device manufactured by the method of the present invention;  
 Fig. 7B is a cross sectional view along line B<sub>4</sub>-B<sub>4</sub>, of the solid state image pickup device manufactured by the method of the present invention;  
 Fig. 7C is a plan view of the solid state image pickup device manufactured by the method of the present invention;  
 Fig. 8 is a plan view explaining the advantageous effects of the solid state image pickup device shown in Fig. 7;  
 Figs. 9A to 9E and Figs. 10A to 10E are cross sectional views showing the processes of manufacturing the solid state image pickup device shown in Figs. 7A to 7C;  
 Fig. 11A is a cross sectional view along line A<sub>5</sub>-A<sub>5</sub>, of a conventional solid state image pickup device;  
 Fig. 11B is a cross sectional view along line B<sub>5</sub>-B<sub>5</sub>, of the conventional solid state image pickup device;  
 Fig. 11C is a plan view of the conventional solid state image pickup device;  
 Fig. 12 is a plan view explaining the disadvantages

of the conventional solid state image pickup device; and

Figs. 13 and 14 are cross sectional views showing the processes of manufacturing conventional solid state image pickup devices.

#### EMBODIMENTS

A solid state image pickup device according to the first embodiment of the present invention will be described with reference to Figs. 1A to 1C and Fig. 2.

The plan view of the solid state image pickup device of the first embodiment is shown in Fig. 1C, the cross sectional view along line A<sub>1</sub>-A<sub>1</sub>, is shown in Fig. 1A, and the cross sectional view along line B<sub>1</sub>-B<sub>1</sub>, is shown in Fig. 1B.

The solid state image pickup device of the first embodiment is constructed of the following elements. Namely, it has a plurality of photodiodes 2 formed on the surface of a semiconductor substrate 1 at predetermined areas, a passivation film (protective film) 3 for protecting the photodiodes, color filters 4<sub>1</sub>, 4<sub>2</sub>, and 4<sub>3</sub> formed on the passivation film 3 for the respective photodiodes 2, a passivation film 5 for protecting the color filters 4<sub>1</sub>, 4<sub>2</sub>, and 4<sub>3</sub>, transparent strip layers 11 formed on the passivation film 5 above the photodiodes 2, and light converging lenses 6' covering the transparent strip layers 11. The photodiodes 2, passivation film 3, color filters 4<sub>1</sub>, 4<sub>2</sub>, and 4<sub>3</sub>, and passivation film 5 are the same as conventional elements, so the description thereof is omitted. The strip layers 11 are made of transparent material and formed running in the Y-direction as seen from Fig. 1C. The cross section of the strip layer 11 along line A-A is rectangular as seen from Fig. 1A. The width of the strip layer 11 in the direction along the longer side of the photodiode 2 (X-direction shown in Fig. 1C) is greater than the width of the photodiode 2 in the X-direction. The length of the strip layer 11 in the Y-direction is set such that it continuously covers a plurality of photodiodes 2 disposed in the Y-direction. Each light converging lens 6' is provided for each photodiode 2, and formed above each strip layer 11. As seen from Fig. 1A, the curvature of the light converging lens 6' at the cross section taken along line A<sub>1</sub>-A<sub>1</sub>, is substantially the same as that of a conventional device. However, as seen from Fig. 1B, the curvature of the light converging lens 6' at the cross section along line B<sub>1</sub>-B<sub>1</sub>, is different. Namely, the thickness of the light converging lens 6' at the cross section along line B-B, i.e., the thickness effective for light convergence, is thinner than that of a conventional device. A desired value of curvature of the light converging lens 6' can be therefore obtained, and almost all light incident to the light converging lens 6' can be converged to the corresponding photodiode 2.

As a result, as shown in Fig. 2, almost all external light 8 incident to the light converging lens 6' can be converged to the photodiode 2 not only in the X-direction but also in the Y-direction, i.e., in the omnidirectional

manner. Therefore, as compared to a conventional device, an effective light convergence area 9 becomes large, improving the light reception sensitivity.

Furthermore, in the first embodiment, as seen from Figs. 1A to 1C, adjacent two light converging lenses 6' are disposed as near as possible, and each light converging lens 6' has a curvature allowing almost all light incident to each light converging lens 6' to be converged to the corresponding photodiode 2. Therefore, an area not allowed for external light to be incident to the photodiode 2 can be made small. For example, consider a conventional solid state image pickup device having a pixel dimension of  $9.6\text{ }\mu\text{m}$  width  $\times$   $9.6\text{ }\mu\text{m}$  height and a photodiode dimension of  $2\text{ }\mu\text{m}$  width  $\times$   $3\text{ }\mu\text{m}$  height. In this case, the width of the invalid light convergence area 10 is about  $2.0\text{ }\mu\text{m}$  at the maximum. In contrast, the width of the invalid light convergence area 10 of the solid state image pickup device of the first embodiment, is as small as about  $0.5\text{ }\mu\text{m}$  at the maximum. From the macro viewpoint, almost all the light receiving section of the solid state image pickup device is substantially covered with a set of light converging lenses 6'. As a result, flare and smear are suppressed, improving the reliability of the solid state image pickup device.

A method of manufacturing the solid state image pickup device of the first embodiment will be described with reference to Figs. 3A to 3D and Figs. 4A to 4D.

Figs. 3A to 3D are cross sectional views along line A<sub>1</sub>-A<sub>1</sub>' of Fig. 1C showing manufacturing processes, and Figs. 4A to 4D are cross sectional views along line B<sub>1</sub>-B<sub>1</sub>'.

In Figs. 3A and 3B, manufacturing processes same as conventional are used until a passivation film 5 is formed.

As seen from Figs. 3B and 4B, a film 11A is formed on the passivation film 5, using styrene based resist or acrylic based resist. This film 11A is patterned to form a plurality of transparent strip layers 11 each having a predetermined dimension and continuously covering a plurality of photodiodes 2, 2, ... disposed in the Y-direction.

Thereafter, as seen from Figs. 3C and 4C, a positive photoresist film 6A is formed covering the strip layers 11. The positive photoresist film 6A is patterned in a predetermined shape by means of a photoetching method. Each patterned positive photoresist film 6 is made transparent, for example, by applying light thereto.

Thereafter, as seen from Figs. 3D and 4D, light converging lenses 6', 6', ... are formed through thermal deformation.

With the above-described manufacturing method, it is possible to obtain the film thickness of the light converging lens 6' at an area effective for light convergence, different in the X-direction and Y-direction, which the conventional device cannot obtain. In this manner, desired curvatures of the light converging lens 6' can be obtained at all the circumference of the lens. Therefore, almost all light incident to the light converging lens 6' can be converged to the corresponding photodiode 2.

Next, a solid state image pickup device according to the second embodiment of the present invention will be described with reference to Figs. 5A to 5C. The plan view of the solid state image pickup device of the second embodiment is shown in Fig. 5C, the cross section taken along line A<sub>2</sub>-A<sub>2</sub>' of Fig. 5C is shown in Fig. 5A, and the cross section taken along line B<sub>2</sub>-B<sub>2</sub>' of Fig. 5C is shown in Fig. 5B.

As seen from Figs. 5A and 5B, the different points of the second embodiment from the first embodiment reside in that a passivation film 11' made of transparent material for protecting transparent layers 11 is formed between the layers 11 and light converging lenses 6', and that the cross section of the strip layer 11 along line A<sub>2</sub>-A<sub>2</sub>' is made generally of a trapezoidal shape. In the second embodiment, like elements to those of the first embodiment are represented by using identical reference numerals, and the description thereof is omitted.

In the second embodiment, the strip layers 11 are covered with the passivation film 11'. Therefore, as the material of the strip layer 11, it is possible to use styrene based or acrylic based negative photoresist, increasing the degree of freedom of material selection. It is preferable to use, as the material of the passivation layer 11', material which does not intermixed with the material of the light converging lens 6'.

The solid state image pickup device of the second embodiment can have desired curvature of the light converging lens 6' and the advantageous effects, similar to the first embodiment. Furthermore, the strip layers 11 are covered with the passivation film 11', so that the strip layers 11, particularly their corners, will not be exposed even if the film thickness of the lens 6' becomes thin, as different from the first embodiment, thus improving the reliability of the device. The third embodiment of the present invention is shown in Figs. 6A to 6C. The plan view of the solid state image pickup device of the third embodiment is shown in Fig. 6C, the cross section taken along line A<sub>3</sub>-A<sub>3</sub>' of Fig. 6C is shown in Fig. 6A, and the cross section taken along line B<sub>3</sub>-B<sub>3</sub>' of Fig. 6C is shown in Fig. 6B.

For the solid state image pickup device of the third embodiment, the processes up to forming a passivation film 5 for protecting color filters 4<sub>1</sub>, 4<sub>2</sub>, and 4<sub>3</sub> are performed in a similar manner to the first embodiment. Thereafter, formed on the passivation film 5 are light converging lenses 6<sub>0</sub>, each constructed of a first light converging lens 6<sub>1</sub>, and a second light converging lens 6<sub>2</sub>. The first light converging lens 6<sub>1</sub>, has a cross section along line A<sub>3</sub>-A<sub>3</sub>' of generally a crescent moon shape. This lens 6<sub>1</sub> extends in the Y-direction to cover a plurality of photodiodes 2, 2, ... disposed in the Y-direction.

The first light converging lens 6<sub>1</sub>, can be considered as a strip layer having a curvature effective for light convergence. As a result, similar to the first and second embodiments, in the third embodiment, the second light converging lenses 6<sub>2</sub>, can be considered as covering the strip layers (first light converging lenses 6<sub>1</sub>). Each sec-

and light converging lens 6<sub>2</sub>, covers the first light converging lens 6<sub>1</sub>, for the corresponding photodiode 2. Therefore, the curvature of the light converging lens 6<sub>0</sub> at the cross section along line A<sub>3</sub>-A<sub>3</sub> is determined by the light converging lenses 6<sub>1</sub> and 6<sub>2</sub>, and the curvature at the cross section along line B<sub>3</sub>-B<sub>3</sub> is determined by the light converging lens 6<sub>2</sub>. It is therefore possible to have desired curvatures at the cross sections along line A<sub>3</sub>-A<sub>3</sub> and line B<sub>3</sub>-B<sub>3</sub>. If adjacent two second light converging lenses 6<sub>2</sub> are disposed as near as possible, the invalid light convergence area 10 can be made small, obtaining the advantageous effects similar to the first embodiment.

In the third embodiment, it is preferable to use as the material of the first light converging lens 6<sub>1</sub>, material which does not intermixed with the material of the second light converging lens 6<sub>2</sub>. For example, material added with thermosetting agent may be used as the material of the first light converging lens 6<sub>1</sub>. Raw material is deformed thermally to obtain the shape of the lens 6<sub>1</sub>, shown in Fig. 6A, and thereafter it is thermally set to form the light converging lens 6<sub>1</sub>. Thereafter, a lens raw material layer is formed on the first light converging lens 6<sub>1</sub>, and etched to form the second light converging lens 6<sub>2</sub>. In this manner, it is possible not to intermix together the materials of the first and second light converging lenses 6<sub>1</sub> and 6<sub>2</sub>.

Also in the third embodiment, the light converging lens 6<sub>0</sub> is constructed of two-layered lenses 6<sub>1</sub> and 6<sub>2</sub>, so that it can be made thicker than a single layer lens. A thick single layer poses a problem of a low patterning precision. However, a multi layer eliminates this problem.

Next, a solid state image pickup device according to the fourth embodiment of the present invention will be described with reference to Figs. 7A to 7C. The plan view of the solid state image pickup device of the fourth embodiment is shown in Fig. 7C, the cross section taken along line A<sub>4</sub>-A<sub>4</sub> of Fig. 7C is shown in Fig. 7A, and the cross section taken along line B<sub>4</sub>-B<sub>4</sub> of Fig. 7C is shown in Fig. 7B.

First, the processes of manufacturing the solid state image pickup device of the fourth embodiment will be described with reference to Figs. 9A to 9E and Figs. 10A to 10E.

Similar to Fig. 3A, as seen from Figs. 9A and 10A, formed on a semiconductor substrate 1 are photodiodes 2, passivation film 3, color filters 4<sub>1</sub>, 4<sub>2</sub>, and 4<sub>3</sub>, and passivation film 5.

As seen from Figs. 9B and 10B, a transparent film layer 106 is formed on the passivation film 5.

As seen from Figs. 9C and 10C, strip layers 11' like the strip layers 11 shown in Fig. 3C are formed on the film layer 106. A resist film 6 like the positive photoresist film 6 shown in Fig. 3C is formed on the strip layers 11'.

Next, as shown in Figs. 9D and 10D, the resist film 6 is heated to obtain the lens shape 6". Since the light converging lens is formed at the later process by etching

a transparent film, the strip layers 11' and lens shape layer 6" are not necessary to use transparent material. Therefore, the degree of freedom of selecting the material for these layers 11' and 6" can be broaden.

Thereafter, as seen from Figs. 9E and 10E, anisotropic etching is carried out using O<sub>2</sub> RIE for example. The lens shape 6" is therefore transferred to a transparent film layer 106 to form light converging lenses 106'.

Similar to the first embodiment, the solid state image pickup device manufactured in the above manner can obtain desired curvatures of the light converging lens 106' at the cross sections along line A<sub>4</sub>-A<sub>4</sub> and line B<sub>4</sub>-B<sub>4</sub>. Therefore, as shown in Fig. 8, almost all light incident to the light converging lens 106' can be converged to the corresponding photodiode 2, considerably improving the light reception sensitivity similar to the first embodiment. In manufacturing a solid state image pickup device, instead of forming strip layers and patterns for light converging lenses as used in the first embodiment, light converging lenses as used in the first embodiment, light converging lenses 106' may be formed by transferring patterns to a transparent film layer by means of anisotropic etching, after forming strip layers and patterns for light converging lenses as used in the second embodiment, or after forming strip layers and patterns for light converging lenses as used in the third embodiment.

In the above embodiments, the cross section of the strip layer has a rectangular shape, trapezoidal shape or crescent moon shape. The present invention is not limited thereto, but any other shape may be used so long as it provides the above-described function of the strip layer.

In the foregoing description, a solid state image pickup device having color filters has been used by way of example. The present invention is not limited thereto. Obviously, the present invention can be applied to solid state image pickup devices without color filters.

## Claims

### 1. A solid state image pickup device comprising:

- a semiconductor substrate (1);
- a plurality of solid state image pickup elements formed on said semiconductor substrate (1), each said solid state image pickup element including a photosensitive section (2) for converting incident light (8) into an electric charge signal, said photosensitive sections (2) being disposed on the surface of said substrate (1) generally in a matrix form, and each said photosensitive section (2) having one side in the row direction longer than the other side in the column direction; and

- a plurality of light converging lenses (6', 11; 6', 11, 11'; 6<sub>1</sub>, 6<sub>2</sub>; 106') formed above said plurality of photosensitive sections (2), each said light converging lens being provided for each said photosensitive section (2), each said light converging lens having a first curvature at a cross section in the row direction and a second curvature at a cross section in the column direction, which are different from each other, and light (8) incident to each said light converging lens in the row and column directions being refracted toward each said photosensitive section (2) corresponding to each said light converging lens;

characterized in that

- each said light converging lens is constructed of a laminated layer of a plurality of layers;
  - each said light converging lens includes an inner layer (11; 6<sub>1</sub>) above each said photosensitive section (2) and an outer layer (6'; 6<sub>2</sub>) covering said inner layer (11; 6<sub>1</sub>); and
  - a plurality of said inner layers (11; 6<sub>1</sub>) of said photosensitive sections disposed in the column direction are continuously coupled to form a strip layer (11; 6<sub>1</sub>).
2. A solid state image pickup device according to claim 1, wherein the cross section of said strip layer (11) in the row direction is generally of a rectangular shape.
  3. A solid state image pickup device according to claim 1, wherein the cross section of said strip layer (6<sub>1</sub>) in the row direction is generally of a semicircular shape.
  4. A solid state image pickup device according to claim 2, wherein said outer layer (6') covers the upper surface and opposite sides of said inner layer (11) at the cross section in the row direction, and covers the upper surface of said inner layer (11) at the cross section in the column direction.
  5. A solid state image pickup device according to claim 2, wherein said outer layer (6') covers the arcuate portion of said inner layer (6<sub>1</sub>) at the cross section in the row direction, and covers the corner portions of said inner layer (6<sub>1</sub>) at the cross section in the column direction.
  6. A solid state image pickup device according to claim 4, wherein each said photosensitive section (2) is formed of a rectangular shape having one side in the row direction longer than the other side in the

column direction.

7. A solid state image pickup device according to claim 5, wherein each said photosensitive section (2) is formed of a rectangular shape having one side in the row direction longer than the other side in the column direction.
8. A solid state image pickup device according to claim 1, wherein color filters (4<sub>1</sub>; 4<sub>2</sub>; 4<sub>3</sub>) are formed between said light converging lenses and corresponding photosensitive sections.
9. A solid state image pickup device according to one of claims 4 and 5, wherein color filters (4<sub>1</sub>; 4<sub>2</sub>; 4<sub>3</sub>) are formed between said light converging lenses and corresponding photosensitive sections.
10. A solid state image pickup device according to claim 1, wherein each said light converging lens (6', 11, 11') includes an inner layer (11) above each said photosensitive section (2), an intermediate layer (11') made of an optional number of layers covering said inner layer (11), and an outer layer (6') covering said intermediate layer (11').
11. A solid state image pickup device according to claim 10, wherein a plurality of said inner layers (11) of said photosensitive sections disposed in the column direction are continuously coupled to form a strip layer (11).
12. A solid state image pickup device according to claim 11, wherein each said inner layer (11) is made of a planar member collectively covering a plurality of upper surfaces of said strip layers and a plurality of gaps between said strip layers.
13. A solid state image pickup device according to claim 12, wherein said outer layer (6') covers said intermediate layer (11') and positioned above said inner layer (11), and the shape of said outer layer (6') is set such that an arcuate portion length at the cross section in the row direction is shorter than an arcuate portion length at the cross section in the column direction.
14. A solid state image pickup device according to claim 13, wherein each said photosensitive section (2) is formed of a rectangular shape having one side in the row direction longer than the other side in the column direction.
15. A solid state image pickup device according to one of claims 10 - 14, wherein color filters (4<sub>1</sub>; 4<sub>2</sub>; 4<sub>3</sub>) are formed between said light converging lenses (6', 11, 11') and corresponding photosensitive sections (2).

16. A solid state image pickup device according to claim 1, wherein said first and second curvatures are given by first thickness at a cross section in the row direction and second thicknesses at a cross section in the column direction. 5
17. A solid state image pickup device according to claim 16, wherein the shape of each said light converging lens (106) being set such that an arcuate portion length at the cross section in the row direction is shorter than an arcuate portion length at the cross section in the column direction. 10
18. A method of manufacturing a solid state image pickup device according to claim 1, comprising the steps of: 15
- forming a plurality of image pickup elements at predetermined areas on the surface of a semiconductor substrate (1), said image pickup elements each having a photosensitive section (2), a plurality of said photosensitive sections (2) being disposed generally in a matrix shape, and each said photosensitive section (2) having one side in the row direction longer than the other side in the column direction; 20 25
  - forming a plurality of transparent strip layers (11) above a plurality of said photosensitive sections (2) of said image pickup elements disposed in the column direction; 30
  - forming a photoresist layer on said semiconductor substrate (1) and said plurality of strip layers (11); 35
  - patterning said photoresist layer to form a plurality of photoresist layer pieces (6) in a matrix form, said plurality of photoresist layer pieces covering said strip layers above said photosensitive sections; and 40
  - thermally deforming each said photoresist layer pieces (6), and by using said thermally deformed photoresist layer pieces (6) and said strip layer (11), forming light converging lenses each having curvatures to refract light (8) incident in the row and column directions toward a corresponding one of said photosensitive sections (2). 45 50
19. A method of manufacturing a solid state image pickup device according to claim 1, comprising the steps of: 55
- forming a plurality of image pickup elements at predetermined areas on the surface of a semiconductor substrate (1), said image pickup elements each having a photosensitive section (2), a plurality of said photosensitive sections (2) being disposed generally in a matrix form, and each said photosensitive section (2) having one side in the row direction longer than the other side in the column direction; 5
  - forming a transparent film layer (106) above said plurality of photosensitive sections (2) for covering said plurality of photosensitive sections; 6
  - forming strip layers (11') on said transparent film layer (106) above said plurality of photosensitive sections (2); 7
  - forming a lens shape defining film on said transparent film layer (106) and said strip layers (11), etching said lens shape defining film to form lens shapes (6'') above each said photosensitive section (2); and 8
  - etching said lens shapes (6''), said strip layers (11'), and said transparent film layer (106), and transferring said lens shape (6'') to said transparent film layer (106) to form a light converging lens (106') above each said photosensitive section (2), said light converging lens having a thickness suitable for refracting light (8) incident to the row and column directions toward a corresponding one of said photosensitive sections (2). 9
20. A method of manufacturing a solid state image pickup device according to claim 18 or 19, further comprising
- a step of forming color filters (4<sub>1</sub>; 4<sub>2</sub>; 4<sub>3</sub>) of optional colors between each said light converging lens (6', 11) 106') and each said photosensitive section (2). 10

#### Patentansprüche

##### 1. Festkörper-Bildaufnahmeverrichtung, mit

- einem Halbleitersubstrat (1);
- einer Vielzahl von auf dem Halbleitersubstrat (1) gebildeten Festkörper-Bildaufnahmeelementen, wobei jedes Festkörper-Bildaufnahmeelement einen fotoempfindlichen Abschnitt (2) zum Umwandeln von einfallendem Licht (8) in ein elektrisches Ladungssignal einschließt, die fotoempfindlichen Abschnitte (2) auf der Oberfläche des Substrats (1) im allgemeinen matrixförmig angeordnet sind, und eine Seite



- eines jeden fotoempfindlichen Abschnittes (2) in der Zeilenrichtung länger ist als die andere Seite in der Spaltenrichtung; und
- einer Vielzahl von lichtbündelnden Linsen (6', 11; 6', 11, 11'; 6<sub>1</sub>', 6<sub>2</sub>', 106), die oberhalb der Vielzahl von fotoempfindlichen Abschnitten (2) gebildet sind, wobei jede lichtbündelnde Linse für einen jeweiligen fotoempfindlichen Abschnitt (2) vorgesehen ist, jede lichtbündelnde Linse eine erste Krümmung an einem Querschnitt in der Zeilenrichtung und eine zweite Krümmung an einem Querschnitt in der Spaltenrichtung aufweist, die voneinander verschieden sind, und auf die jeweilige lichtbündelnde Linse in den Zeilen- und Spaltenrichtungen einfallendes Licht (8) auf den jeweiligen fotoempfindlichen Abschnitt (2) entsprechend der jeweiligen lichtbündelnden Linse hin gebrochen wird;
- dadurch gekennzeichnet, daß
- jede lichtbündelnde Linse aus einer laminierten Schicht aus einer Vielzahl von Schichten konstruiert ist;
  - jede lichtbündelnde Linse eine innere Schicht (11; 6<sub>1</sub>') oberhalb des jeweiligen fotoempfindlichen Abschnittes (2) und eine äußere Schicht (6', 6<sub>2</sub>'), die die innere Schicht (11; 6<sub>1</sub>') bedeckt, einschließt; und
  - eine Vielzahl von inneren Schichten (11; 6<sub>1</sub>') der in der Spaltenrichtung angeordneten, fotoempfindlichen Abschnitte kontinuierlich gekoppelt sind, eine Streifenschicht (11; 6<sub>1</sub>') zu bilden.
2. Festkörper-Bildaufnahmeverrichtung nach Anspruch 1, dadurch gekennzeichnet, daß der Querschnitt der Streifenschicht (11) in der Zeilenrichtung eine allgemein rechteckige Gestalt hat.
  3. Festkörper-Bildaufnahmeverrichtung nach Anspruch 1, dadurch gekennzeichnet, daß der Querschnitt der Streifenschicht (6<sub>1</sub>') in der Zeilenrichtung eine allgemein halbkreisförmige Gestalt hat.
  4. Festkörper-Bildaufnahmeverrichtung nach Anspruch 2, dadurch gekennzeichnet, daß die äußere Schicht (6') die obere Oberfläche und gegenüberliegende Seiten der inneren Schicht (11) an dem Querschnitt in der Zeilenrichtung bedeckt, und die obere Oberfläche der inneren Schicht (11) an dem Querschnitt in der Spaltenrichtung bedeckt.
  5. Festkörper-Bildaufnahmeverrichtung nach Anspruch 2, dadurch gekennzeichnet, daß die äußere

Schicht (6') den gekrümmten Abschnitt der inneren Schicht (6<sub>1</sub>') an dem Querschnitt in der Zeilenrichtung bedeckt, und die Eckabschnitte der inneren Schicht (6<sub>1</sub>') an dem Querschnitt in der Spaltenrichtung bedeckt.

6. Festkörper-Bildaufnahmeverrichtung nach Anspruch 4, dadurch gekennzeichnet, daß jeder fotoempfindliche Abschnitt (2) mit einer rechteckigen Gestalt gebildet ist, wobei eine Seite in der Zeilenrichtung länger ist als die andere Seite in der Spaltenrichtung.
7. Festkörper-Bildaufnahmeverrichtung nach Anspruch 5, dadurch gekennzeichnet, daß jeder fotoempfindliche Abschnitt (2) mit einer rechteckigen Gestalt gebildet ist, wobei eine Seite in der Zeilenrichtung länger ist als die andere Seite in der Spaltenrichtung.
8. Festkörper-Bildaufnahmeverrichtung nach Anspruch 1, dadurch gekennzeichnet, daß Farbfilter (4<sub>1</sub>; 4<sub>2</sub>; 4<sub>3</sub>) zwischen den lichtbündelnden Linsen und entsprechenden fotoempfindlichen Abschnitten gebildet sind.
9. Festkörper-Bildaufnahmeverrichtung nach einem der Ansprüche 4 und 5, dadurch gekennzeichnet, daß Farbfilter (4<sub>1</sub>; 4<sub>2</sub>; 4<sub>3</sub>) zwischen den lichtbündelnden Linsen und entsprechenden fotoempfindlichen Abschnitten gebildet sind.
10. Festkörper-Bildaufnahmeverrichtung nach Anspruch 1, dadurch gekennzeichnet, daß jede lichtbündelnde Linse (6', 11, 11') eine innere Schicht (11) oberhalb eines jeweiligen fotoempfindlichen Abschnittes (2) einschließt, eine Zwischenschicht (11') aus einer optionalen Anzahl von Schichten, die die innere Schicht (11) bedeckt, und eine äußere Schicht (6'), die die Zwischenschicht (11') bedeckt.
11. Festkörper-Bildaufnahmeverrichtung nach Anspruch 10, dadurch gekennzeichnet, daß eine Vielzahl der inneren Schichten (11) der in der Spaltenrichtung angeordneten, fotoempfindlichen Abschnitte kontinuierlich gekoppelt sind, eine Streifenschicht (11) zu bilden.
12. Festkörper-Bildaufnahmeverrichtung nach Anspruch 11, dadurch gekennzeichnet, daß jede innere Schicht (11) aus einem planaren Teil gebildet ist, das kollektiv eine Vielzahl von oberen Oberflächen der Streifenschichten und eine Vielzahl von Spalten zwischen den Streifenschichten bedeckt.
13. Festkörper-Bildaufnahmeverrichtung nach Anspruch 12, dadurch gekennzeichnet, daß die äußere Schicht (6') die Zwischenschicht (11') bedeckt

und oberhalb der inneren Schicht (11) positioniert ist, und die Gestalt der äußeren Schicht (6') so eingestellt ist, daß eine Länge eines gebogenen Abschnittes an dem Querschnitt in der Zeilenrichtung kürzer ist als die Länge eines gebogenen Abschnittes an dem Querschnitt in der Spaltenrichtung.

14. Festkörper-Bildaufnahmeverrichtung nach Anspruch 13, dadurch gekennzeichnet, daß jeder fotoempfindliche Abschnitt (2) mit einer rechtwinkligen Gestalt gebildet ist, wobei eine Seite in der Zeilenrichtung länger ist als die andere Seite in der Spaltenrichtung.

15. Festkörper-Bildaufnahmeverrichtung nach einem der Ansprüche 10 bis 14, dadurch gekennzeichnet, daß Farbfiler (4<sub>1</sub>; 4<sub>2</sub>; 4<sub>3</sub>) zwischen den lichtbündelnden Linsen (6', 11, 11') und entsprechenden fotoempfindlichen Abschnitten (2) gebildet sind.

16. Festkörper-Bildaufnahmeverrichtung nach Anspruch 1, dadurch gekennzeichnet, daß die ersten und zweiten Krümmungen durch eine erste Dicke an einem Querschnitt in der Zeilenrichtung und eine zweite Dicke an einem Querschnitt in der Spaltenrichtung gegeben sind.

17. Festkörper-Bildaufnahmeverrichtung nach Anspruch 16, dadurch gekennzeichnet, daß die Gestalt einer jeden lichtbündelnden Linse (106) so eingestellt ist, daß die Länge eines gebogenen Abschnittes an dem Querschnitt in der Zeilenrichtung kürzer ist als die Länge eines gebogenen Abschnittes an dem Querschnitt in der Spaltenrichtung.

18. Verfahren zum Herstellen einer Festkörper-Bildaufnahmeverrichtung nach Anspruch 1, mit den Schritten:

- Bilden einer Vielzahl von Bildaufnahmeelementen an vorbestimmten Gebieten auf der Oberfläche eines Halbleitersubstrats (1), wobei die Bildaufnahmeelemente jeweils einen fotoempfindlichen Abschnitt (2) aufweisen, eine Vielzahl der fotoempfindlichen Abschnitte (2) allgemein matrixförmig angeordnet ist, und eine Seite eines jeden fotoempfindlichen Abschnittes (2) in der Zeilenrichtung länger ist als die andere Seite in der Spaltenrichtung;
- Bilden einer Vielzahl von transparenten Streifenschichten (11) oberhalb einer Vielzahl der fotoempfindlichen Abschnitte (2) der in der Spaltenrichtung angeordneten Bildaufnahmeelemente;
- Bilden einer Fotoresistschicht auf dem Halbleitersubstrat (1) und der Vielzahl von Streifen-

schichten (11);

- Strukturieren der Fotoresistschicht, um eine Vielzahl von Fotoresistschichtstücken (6) in Matrixform zu bilden, wobei die Vielzahl von Fotoresistschichtstücken die Streifenschichten oberhalb der fotoempfindlichen Abschnitte bedecken; und
- thermisch Deformieren eines jeden Fotoresistschichtstückes (6), und mittels Verwendens der thermisch deformierten Fotoresistschichtstücke (6) und der Streifenschicht (11), Bilden von lichtbündelnden Linsen, von denen jede Krümmungen aufweist, in den Zeilen- und Spaltenrichtungen einfallendes Licht (8) auf einen entsprechenden der fotoempfindlichen Abschnitte (2) hin zu brechen.

19. Verfahren zum Herstellen einer Festkörper-Bildaufnahmeverrichtung nach Anspruch 1, mit den Schritten:

- Bilden einer Vielzahl von Bildaufnahmeelementen an vorbestimmten Gebieten auf der Oberfläche eines Halbleitersubstrats (1), wobei die Bildaufnahmeelemente jeweils einen fotoempfindlichen Abschnitt (2) aufweisen, eine Vielzahl der fotoempfindlichen Abschnitte (2) allgemein matrixförmig angeordnet ist, und eine Seite eines jeden fotoempfindlichen Abschnittes (2) in der Zeilenrichtung länger ist als die andere Seite in der Spaltenrichtung;
- Bilden einer Transparentfilmschicht (106) oberhalb der Vielzahl von fotoempfindlichen Abschnitten (2), um die Vielzahl von fotoempfindlichen Abschnitten zu bedecken;
- Bilden von Streifenschichten (11') auf der transparenten Filmschicht (106) oberhalb der Vielzahl von fotoempfindlichen Abschnitten (2);
- Bilden eines eine Linsengestalt definierenden Films auf der Transparentfilmschicht (106) und den Streifenschichten (11), Ätzen des eine Linsengestalt definierenden Films, um Linsengestalten (6') oberhalb eines jeden fotoempfindlichen Abschnittes (2) zu bilden; und
- Ätzen der Linsengestalt (6'), der Streifenschichten (11') und der Transparentfilmschicht (106), und Übertragen der Linsengestalt (6') auf die Transparentfilmschicht (106), um eine lichtbündelnde Linse (106') oberhalb eines jeden fotoempfindlichen Abschnittes (2) zu bilden, wobei die lichtbündelnde Linse eine zum Brechen von in den Zeilen- und Spaltenrichtun-

gen einfallendem Licht (8) zu einem entsprechenden der fotoempfindlichen Abschnitte (2) hin geeignete Dicke aufweisen.

20. Verfahren zum Herstellen einer Festkörper-Bildaufnahmevorrichtung nach Anspruch 18 oder 19, gekennzeichnet durch

- einen Schritt des Bildens von Farbfiltern (4<sub>1</sub>; 4<sub>2</sub>; 4<sub>3</sub>) mit gewünschten Farben zwischen den jeweiligen lichtbündelnden Linsen (6', 11, 106') und dem jeweiligen fotoempfindlichen Abschnitt (2).

#### Revendications

1. Dispositif capteur d'image du type état solide, comprenant :

- un substrat semiconducteur (1) ;
- une pluralité d'éléments capteurs d'image du type état solide formés sur ledit substrat semiconducteur (1), chaque dit élément capteur d'image du type état solide comportant une section photosensible (2) qui sert à convertir la lumière incidente (8) en un signal de charges électriques, lesdites sections photosensibles (2) étant disposées sur la surface dudit substrat (1) sensiblement sous forme d'une matrice, et chaque dite section photosensible (2) ayant un côté, suivant la direction des rangées, plus long que l'autre côté, se trouvant suivant la direction des colonnes ; et
- une pluralité de lentilles (6', 11 ; 6', 11, 11' ; 6<sub>1</sub>, 6<sub>2</sub> ; 106') servant à faire converger la lumière, qui sont formées au-dessus de ladite pluralité de sections photosensibles (2), une dite lentille de convergence lumineuse étant prévue pour chaque dite section photosensible (2), chaque dite lentille de convergence lumineuse ayant une première courbure en une section droite dans la direction des rangées et une deuxième courbure en une section droite dans la direction des colonnes, lesquelles sont différentes l'une de l'autre, et la lumière (8) qui arrive sur chaque dite lentille de convergence lumineuse suivant les directions des rangées et des colonnes étant réfractée en direction de la dite section photosensible (2) qui correspond à cette dite lentille de convergence lumineuse ;

caractérisé en ce que :

- chaque dite lentille de convergence lumineuse est constituée d'une couche stratifiée faite d'une pluralité de couches ;
- chaque dite lentille de convergence lumineuse

comporte une couche interne (11 ; 6<sub>1</sub>) au-dessus de la dite section photosensible (2) qui lui correspond et une couche externe (6' ; 6<sub>2</sub>) couvrant ladite couche interne (11 ; 6<sub>1</sub>) ; et

- une pluralité desdites couches internes (11 ; 6<sub>1</sub>) desdites sections photosensibles disposées suivant la direction des colonnes sont couplées de façon continue afin de former une couche en forme de bande (11 ; 6<sub>1</sub>).

2. Dispositif capteur d'image du type état solide selon la revendication 1, où la section droite de ladite couche en forme de bande (11) suivant la direction des rangées est sensiblement de forme rectangulaire.

3. Dispositif capteur d'image du type état solide selon la revendication 1, où la section droite de ladite couche en forme de bande (6<sub>1</sub>) suivant la direction des rangées est sensiblement de forme semi-circulaire.

4. Dispositif capteur d'image du type état solide selon la revendication 2, où ladite couche externe (6') couvre la surface supérieure et les côtés opposés de ladite couche interne (11) au niveau de la section droite suivant la direction des rangées, et couvre la surface supérieure de ladite couche interne (11) au niveau de la section droite suivant la direction des colonnes.

5. Dispositif capteur d'image du type état solide selon la revendication 2, où ladite couche externe (6') couvre la partie incurvée de ladite couche interne (6<sub>1</sub>) au niveau de la section droite suivant la direction des rangées, et couvre les parties coins de ladite couche interne (6<sub>1</sub>) au niveau de la section droite suivant la direction des colonnes.

6. Dispositif capteur d'image du type état solide selon la revendication 4, où chaque dite section photosensible (2) présente une forme rectangulaire qui possède un côté, suivant la direction des rangées, plus long que l'autre côté, se trouvant dans la direction des colonnes.

7. Dispositif capteur d'image du type état solide selon la revendication 5, où chaque dite section photosensible (2) présente une forme rectangulaire qui possède un côté, suivant la direction des rangées, plus long que l'autre côté, se trouvant dans la direction des colonnes.

8. Dispositif capteur d'image du type état solide selon la revendication 1, où des filtres colorés (4<sub>1</sub> ; 4<sub>2</sub> ; 4<sub>3</sub>) sont formés entre lesdites lentilles de convergence lumineuse et les sections photosensibles correspondantes.

9. Dispositif capteur d'image du type état solide selon

l'une quelconque des revendications 4 et 5, où des filtres colorés ( $4_1$  ;  $4_2$  ;  $4_3$ ) sont formés entre lesdites lentilles de convergence lumineuse et les sections photosensibles correspondantes.

10. Dispositif capteur d'image du type état solide selon la revendication 1, où chaque dite lentille de convergence lumineuse ( $6'$ ,  $11$ ,  $11'$ ) comporte une couche interne ( $11$ ) se trouvant au-dessus de la dite section photosensible (2) qui lui correspond, une couche intermédiaire ( $11'$ ) faite d'un nombre, qu'on peut fixer librement, de couches couvrant ladite couche interne ( $11$ ), et une couche externe ( $6'$ ) couvrant ladite couche intermédiaire ( $11'$ ).

11. Dispositif capteur d'image du type état solide selon la revendication 10, où une pluralité desdites couches internes ( $11$ ) desdites sections photosensibles disposées dans la direction des colonnes sont couplées de façon continue afin de former une couche en forme de bande ( $11$ ).

12. Dispositif capteur d'image du type état solide selon la revendication 11, où chaque dite couche interne ( $11$ ) est faite d'un élément plan qui couvre collectivement une pluralité de surfaces supérieures desdites couches en forme de bande et une pluralité d'intervalles entre lesdites couches en forme de bandes.

13. Dispositif capteur d'image du type état solide selon la revendication 12, où ladite couche externe ( $6'$ ) couvre ladite couche intermédiaire ( $11'$ ) et est positionnée au-dessus de ladite couche interne ( $11$ ), et la forme de ladite couche externe ( $6'$ ) est ajustée de façon que la longueur de partie incurvée se trouvant au niveau de la section droite suivant la direction des rangées est plus courte que la longueur de partie incurvée se trouvant au niveau de la section droite suivant la direction des colonnes.

14. Dispositif capteur d'image du type état solide selon la revendication 13, où chaque dite section photosensible (2) présente une forme rectangulaire ayant un côté, suivant la direction des rangées, qui est plus long que l'autre côté, se trouvant suivant la direction des colonnes.

15. Dispositif capteur d'image du type état solide selon l'une quelconque des revendications 10 à 14, où des filtres colorés ( $4_1$  ;  $4_2$  ;  $4_3$ ) sont formés entre lesdites lentilles de convergence lumineuse ( $6'$ ,  $11$ ,  $11'$ ) et les sections photosensibles correspondantes (2).

16. Dispositif capteur d'image du type état solide selon la revendication 1, où lesdites première et deuxième courbures sont données par une première

épaisseur se trouvant en une section droite suivant la direction des rangées et une deuxième épaisseur se trouvant en une section droite suivant la direction des colonnes.

17. Dispositif capteur d'image du type état solide selon la revendication 16, où ladite forme de chaque lentille de convergence lumineuse ( $106$ ) est ajustée de façon que la longueur de partie incurvée se trouvant au niveau de la section droite suivant la direction des rangées est plus courte que la longueur de partie incurvée se trouvant au niveau de la section droite suivant la direction des colonnes.

18. Procédé de fabrication d'un dispositif capteur d'image du type état solide selon la revendication 1, comprenant les opérations suivantes :

- former une pluralité d'éléments capteurs d'image en des aires prédéterminées de la surface d'un substrat semiconducteur (1), lesdits éléments capteurs d'image ayant chacun une section photosensible (2), une pluralité desdites sections photosensibles (2) étant disposées sensiblement suivant une forme matricielle, et chaque dite section photosensible (2) ayant un côté, suivant la direction des rangées, qui est plus long que l'autre côté, se trouvant suivant la direction des colonnes ;
- former une pluralité de couches en forme de bandes transparentes ( $11$ ) au-dessus d'une pluralité desdites sections photosensibles (2) desdits éléments capteurs d'image disposés suivant la direction des colonnes ;
- former une couche d'agent photosensible, dite couche de photorésist, sur ledit substrat semiconducteur (1) et ladite pluralité de couches en forme de bandes ( $11$ );
- appliquer un tracé de motifs à ladite couche de photorésist afin de former une pluralité de morceaux (6) de couche de photorésist suivant une forme matricielle, ladite pluralité de morceaux de couche de photorésist couvrant lesdites couches en forme de bandes qui sont au-dessus desdites sections photosensibles ; et
- déformer thermiquement chacun desdits morceaux (6) de couche de photorésist et, en utilisant lesdits morceaux (6) de couche de photorésist thermiquement déformés et ladite couche en forme de bande ( $11$ ), former des lentilles servant à faire converger la lumière qui ont chacune des courbures de nature à réfracter la lumière (8) arrivant suivant les directions des rangées et des colonnes vers l'une, correspondante, desdites sections photosensibles (2).

19. Procédé de fabrication d'un dispositif capteur d'image du type état solide selon la revendication 1, com-

prenant les opérations suivantes :

- former une pluralité d'éléments capteurs d'image en des aires prédéterminées de la surface d'un substrat semiconducteur (1), lesdits éléments capteurs d'image ayant chacun une section photosensible (2), une pluralité desdites sections photosensibles (2) étant disposées sensiblement suivant une forme matricielle, et chaque dite section photosensible (2) ayant un côté, suivant la direction des rangées, qui est plus long que l'autre côté, se trouvant suivant la direction des colonnes ; 5
- former une couche de pellicule transparente (106) au-dessus de ladite pluralité de sections photosensibles (2) afin de couvrir ladite pluralité de sections photosensibles ; 10
- former des couches en forme de bandes (11') sur ladite couche de pellicule transparente (106) au-dessus de ladite pluralité de sections photosensibles (2) ; 15
- former une pellicule définissant des formes de lentilles sur ladite couche de pellicule transparente (106) et lesdites couches en forme de bandes (11), graver ladite pellicule définissant des formes de lentilles afin de former des formes de lentilles (6") au-dessus de chaque dite section photosensible (2) ; et 20
- graver lesdites formes de lentilles (6"), lesdites couches en forme de bandes (11') et ladite couche de pellicule transparente (106), et transférer ladite forme de lentille (6") à ladite couche de pellicule transparente (106) afin de former une lentille (106'), servant à faire converger la lumière, au-dessus de chaque dite section photosensible (2), ladite lentille de convergence lumineuse ayant une épaisseur adaptée à réfracter la lumière (8) qui arrive suivant les directions des rangées et des colonnes vers l'une, correspondante, desdites sections photosensibles (2). 25 30 35 40

20. Procédé de fabrication d'un dispositif capteur d'image du type état solide selon la revendication 18 ou 19, comprenant en outre une opération de formation de filtres colorés ( $4_1$  ;  $4_2$  ;  $4_3$ ), de couleur pouvant être choisie librement, entre chaque dite lentille de convergence lumineuse (6', 11, 106') et la dite section photosensible (2) qui lui correspond. 45

50

55

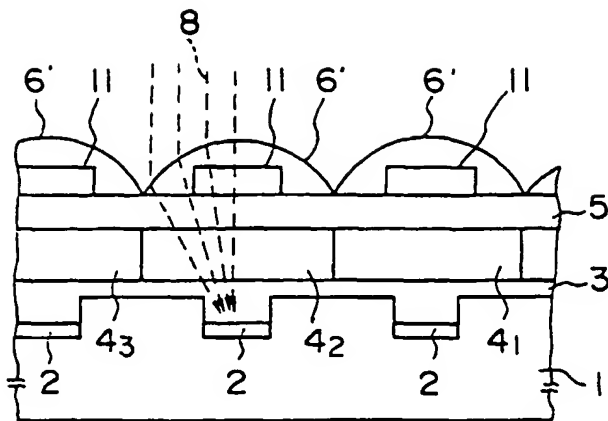


FIG. 1A

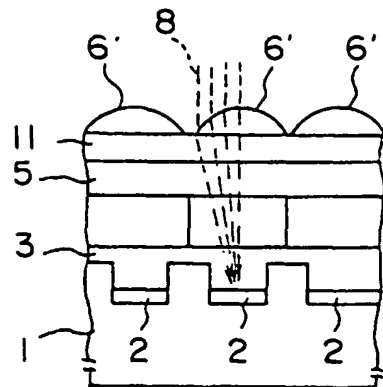


FIG. 1B

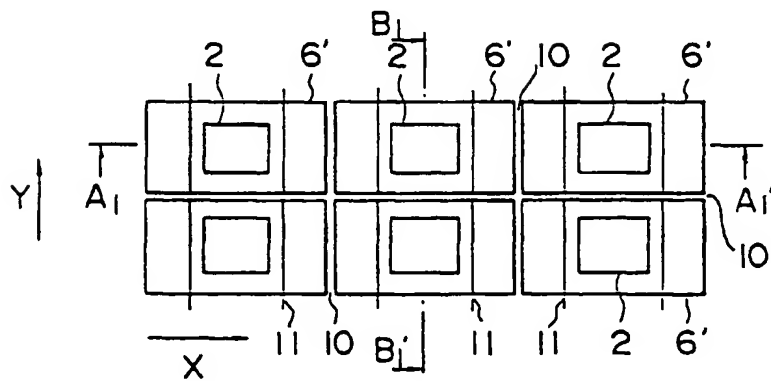


FIG. 1C

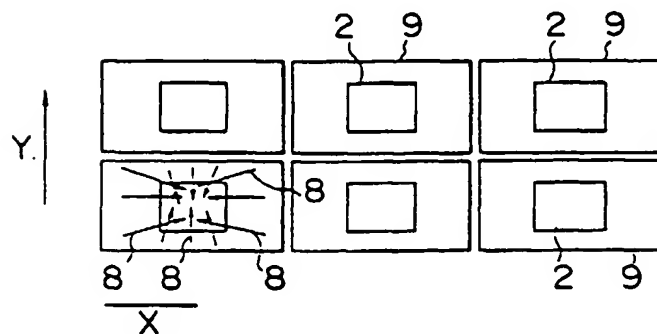


FIG. 2

FIG. 3A

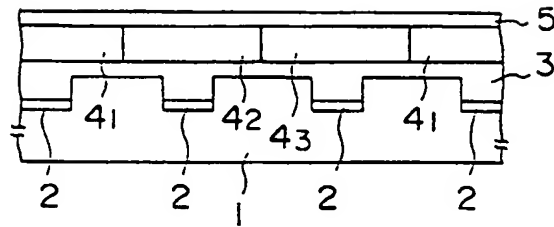


FIG. 3B

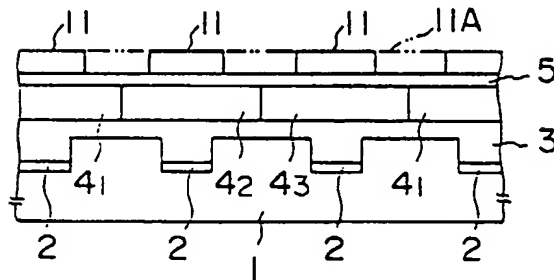


FIG. 3C

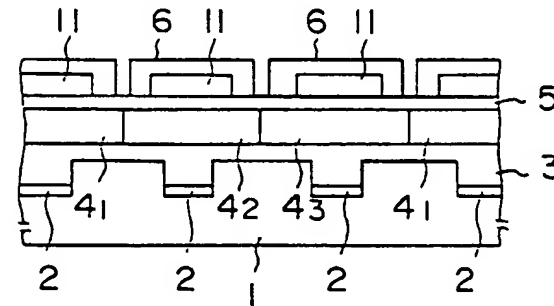
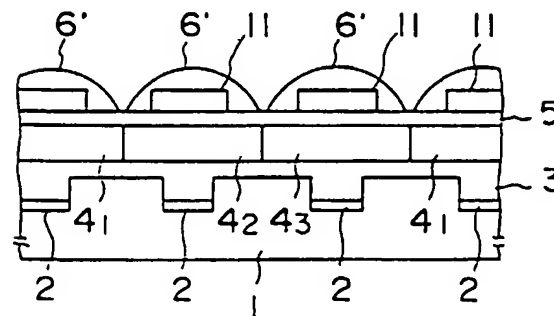
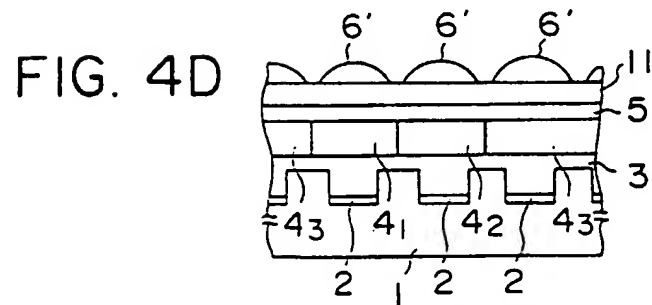
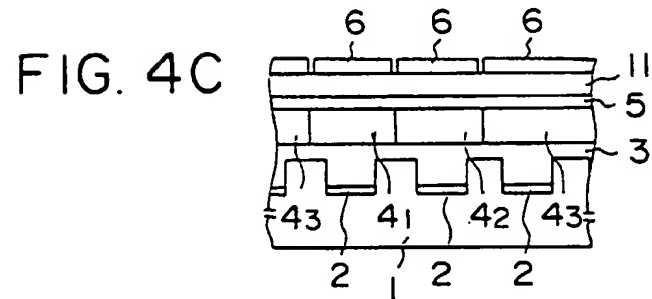
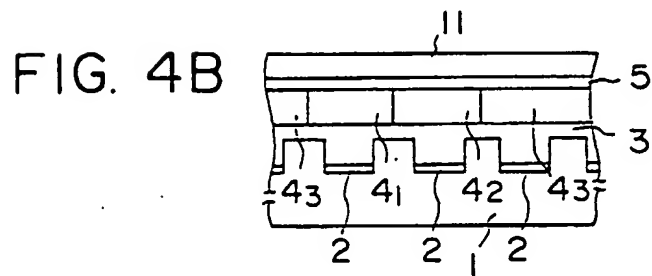
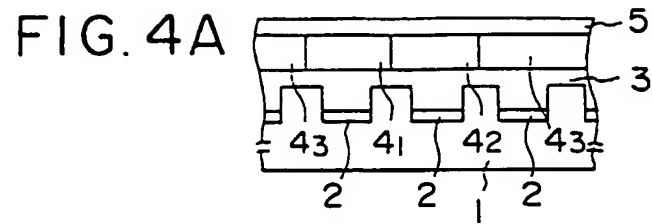


FIG. 3D







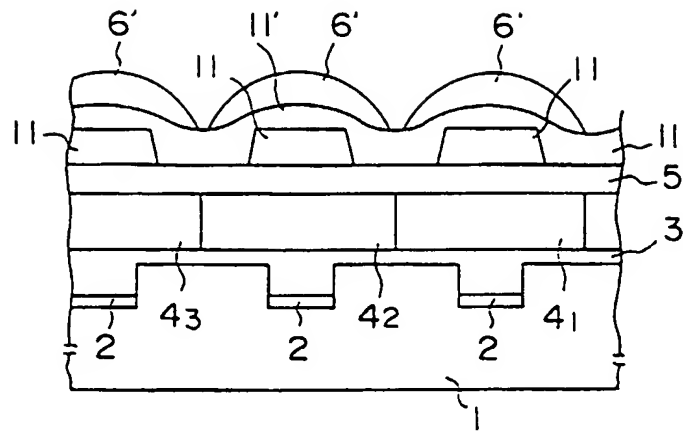


FIG. 5A

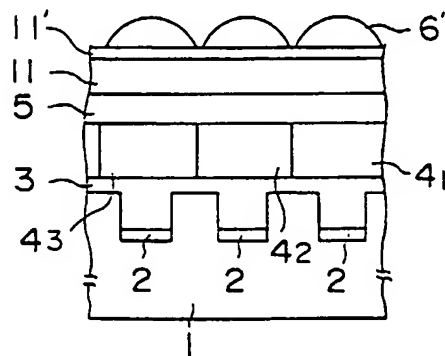


FIG. 5B

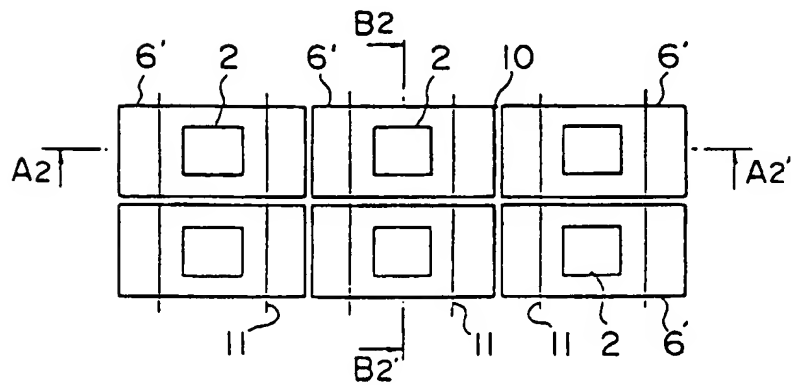


FIG. 5C

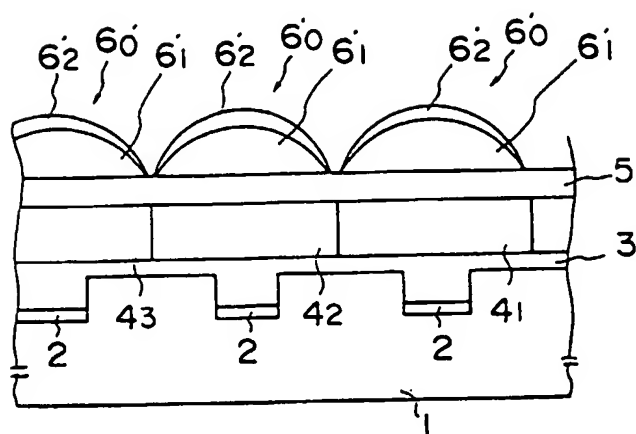


FIG. 6A

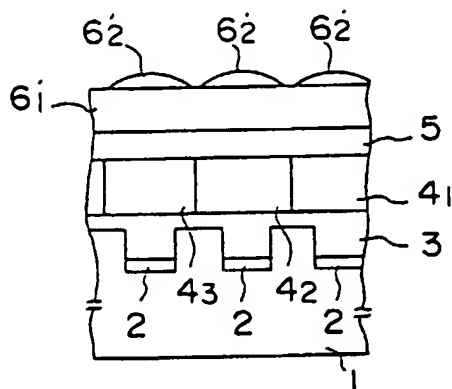


FIG. 6B

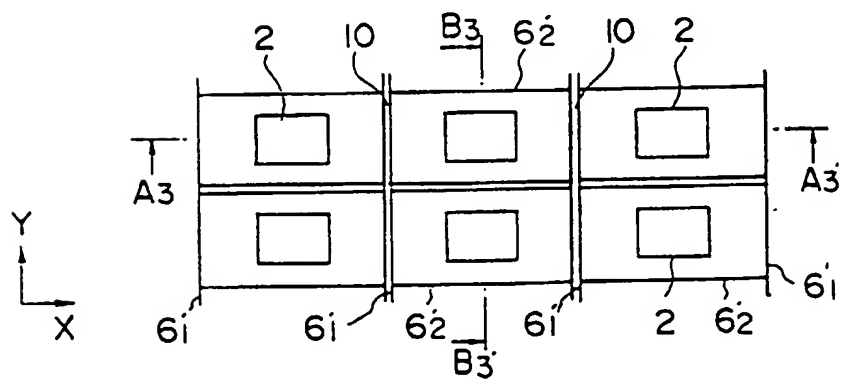


FIG. 6C

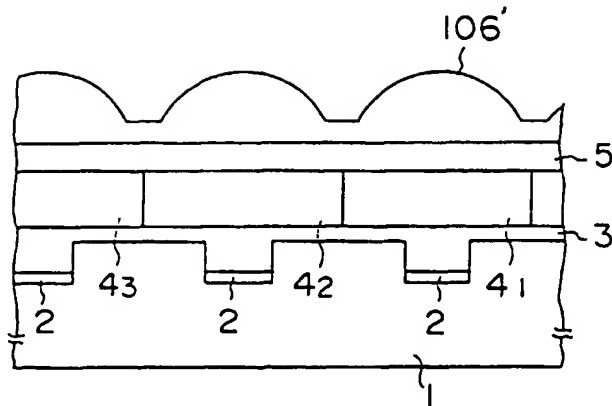


FIG. 7A

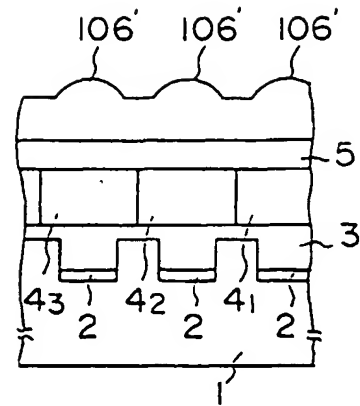


FIG. 7B

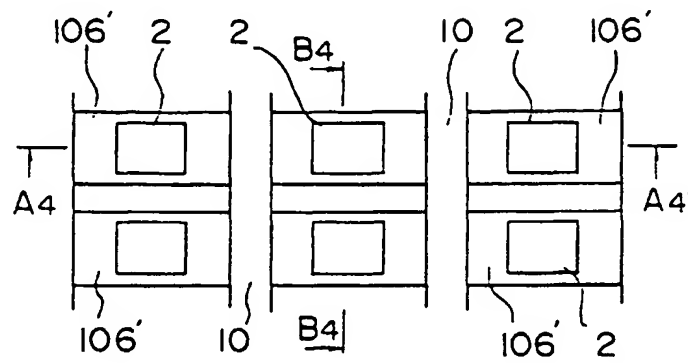


FIG. 7C

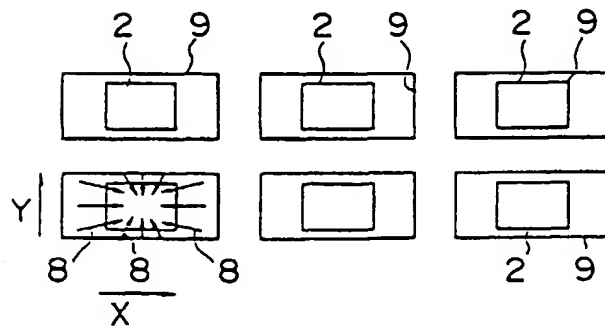


FIG. 8

FIG. 9A

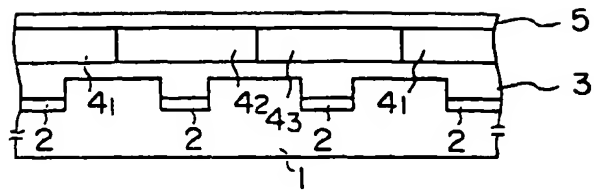


FIG. 9B

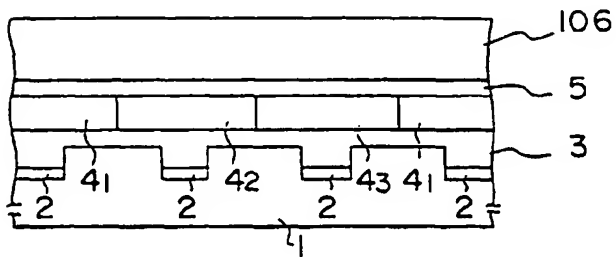


FIG. 9C

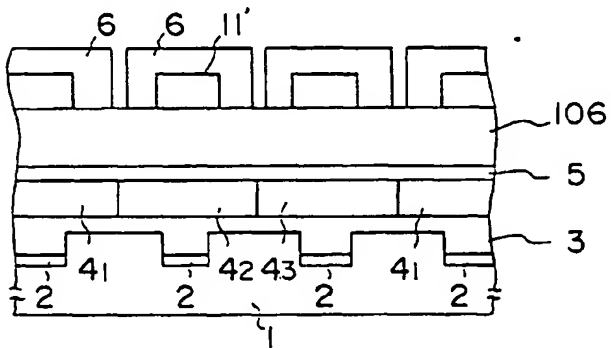


FIG. 9D

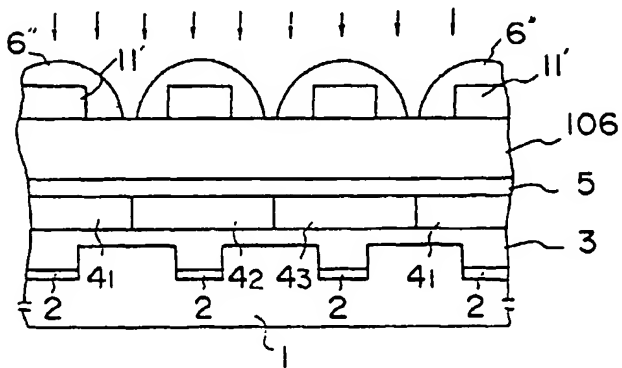


FIG. 9E

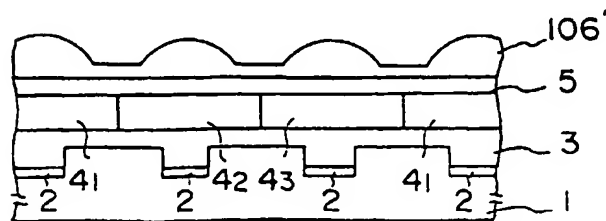


FIG. 10A

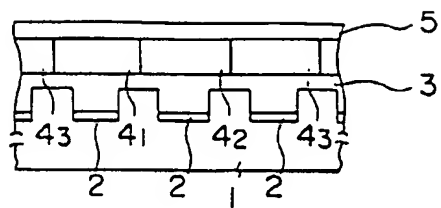


FIG. 10B

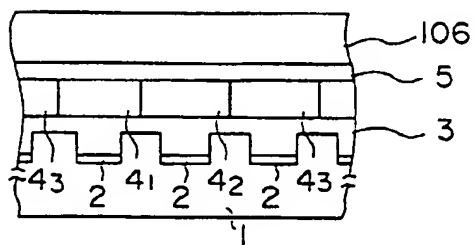


FIG. 10C

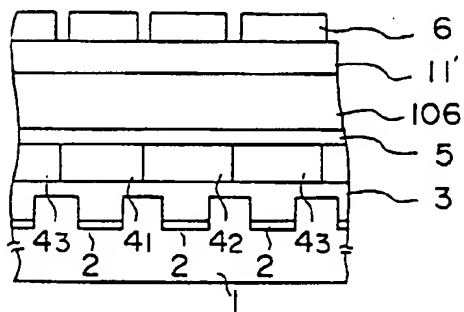


FIG. 10D

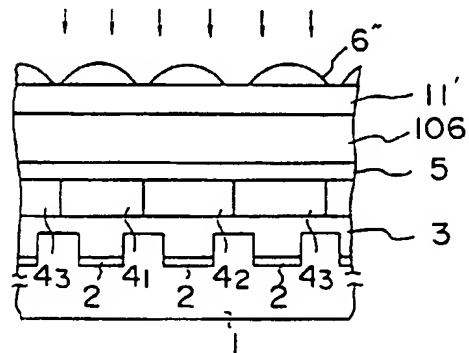
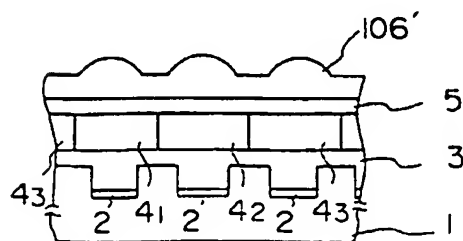


FIG. 10E



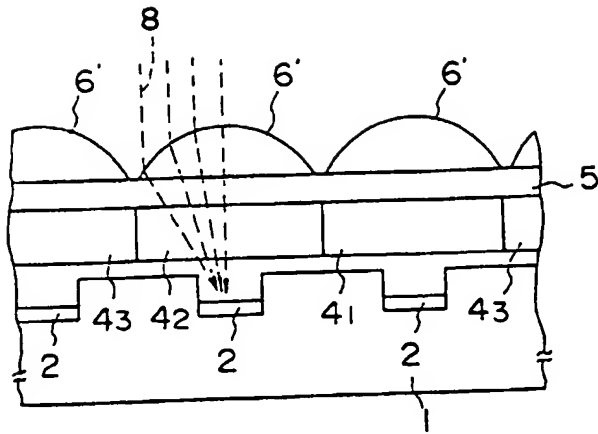


FIG. IIA

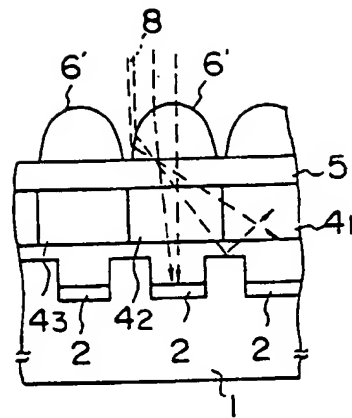


FIG. IIB

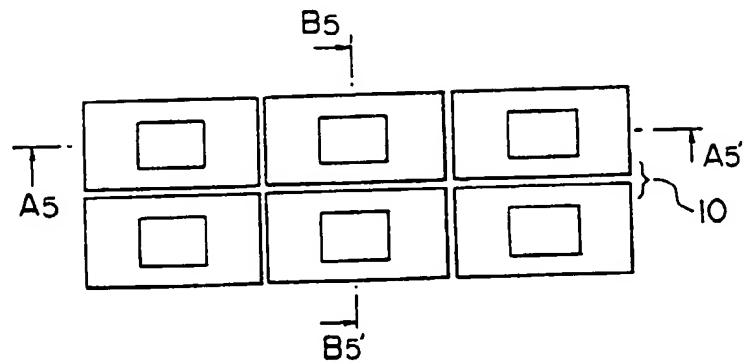


FIG. IIC

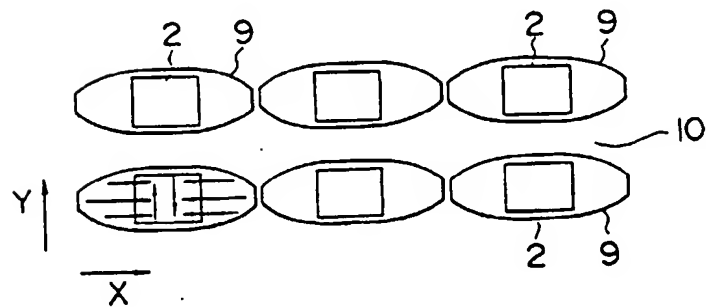


FIG. 12

FIG. 13A

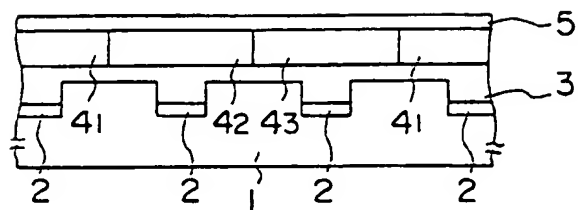


FIG. 13B

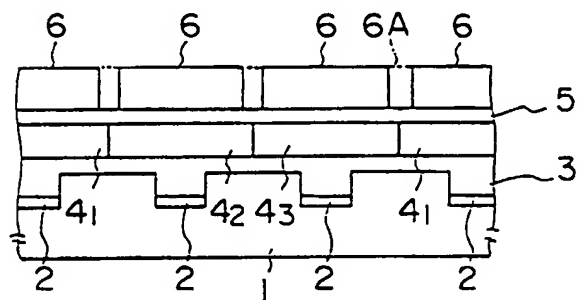


FIG. 13C

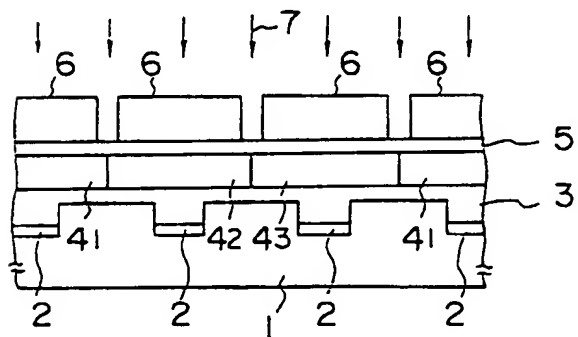


FIG. 13D

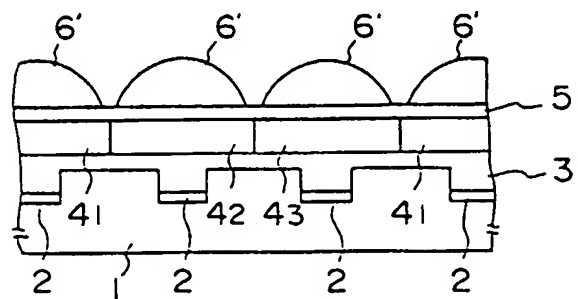


FIG. 14A

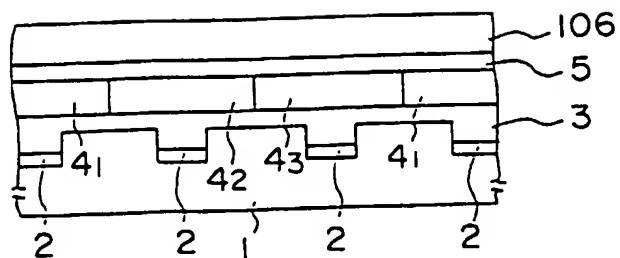


FIG. 14B

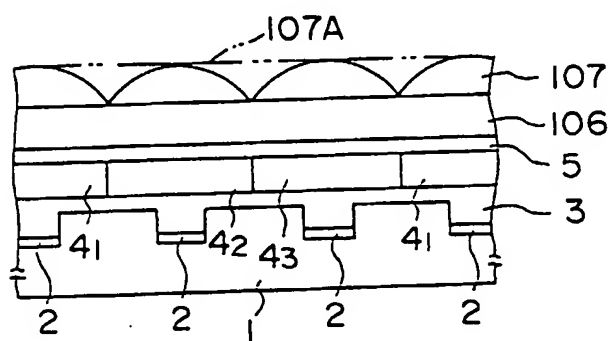


FIG. 14C

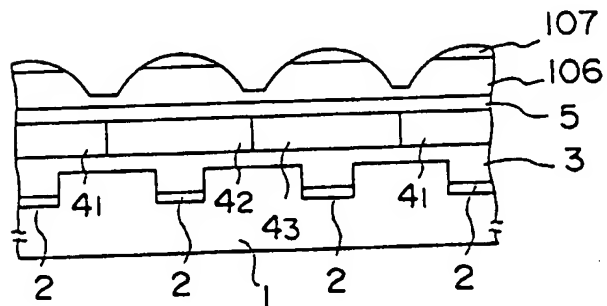


FIG. 14D

